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International experience on incentive program in support of fuel economy standards and labelling for motor vehicle: A comprehensive review

T.M.I. Mahlia [a,b,*], S. Tohno [c], T. Tezuka [c]

[a] Department of Mechanical Engineering, Universiti Tenaga Nasional, 43000 Kajang, Selangor, Malaysia
[b] Department of Mechanical Engineering, University of Malaya, 50603 Kuala Lumpur, Malaysia
[c] Department of Socio-environmental Energy Science Graduate School of Energy Science, Kyoto University Yoshida-honmachi Sakyo-ku, Kyoto 606-8501, Japan

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ABSTRACT

The road transports especially the motor vehicles play a significant role in increment of energy consumption in the transportation sector. However, the harmful greenhouse gas (GHG) emissions from such vehicles which are the main causes of global warming, have been increased as well. One of the effective solutions to reduce the growth rate of energy consumption is the implementation of fuel economy standard and label. Other countries' experiences indicate that the program is very beneficial for society, environment and government. The hierarchy of the program consists of the test procedure, fuel economy standards, fuel economy label and incentive program as a peak of the program. Reviews of the fuel economy standard can be found in many references. However, a few papers deal with the incentive program specifically. Therefore, this paper aims to give a review on the implementation of the incentive program globally in support of fuel economy standard and label for the motor vehicles. Finally, as the incentive program is necessary to support fuel economy standard and label, it should be applied to the motor vehicles as soon as possible.

Contents

1. Introduction

Energy conversion process accounted for a significant amount of greenhouse gas emission around the world. These gasses cause the global warming which leads to climate change [1–3]. Reducing the

* Corresponding author at: Department of Mechanical Engineering, Universiti Tenaga Nasional, 43000 Kajang, Selangor, Malaysia. Tel.: +60 3 8928 7221; fax: +60 3 8928 2116.
E-mail addresses: i_mahlia@hotmail.com, indra@uniten.edu.my, indra@um.edu.my (T.M.I. Mahlia).

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effects of climate change has become one of the most important objectives for the policy makers. It can be achieved by designing a platform that provides a suitable incentive program for consumers and manufacturers to improve the fuel economy of the vehicles. This platform can reduce emissions, especially carbon dioxide, indirectly [4]. To achieve this objective, the policy makers should implement the program as soon as possible and it is necessary to keep the balance of competitiveness and sustainability [5]. At the first glance, investment to improve energy efficiency seems to be very easy and beneficial. However, in reality, after implementation of the program, some barriers will appear. Awareness and consideration of these barriers are essential for designing more effective policies [6].

An incentive program can be defined as a formal scheme used to promote or encourage specific actions and behaviors of a group of people during a defined period of time [7]. The incentive programs are usually introduced to encourage using more efficient products. These programs have been widely implemented in home appliances to motivate manufacturers to produce and consumers to purchase more efficient products. Some works related to the incentive programs for energy efficiency improvement, including its impact analysis are discussed thoroughly in Refs. [8–22].

In the beginning, the incentive programs have been introduced in some countries to encourage the end-user to purchase efficient home appliances. In the United States, new home appliances which are offered as an incentive program, must meet certain criteria of ENERGY STAR®. Some of the incentive programs for home appliances are presented in Table 1 [23].

Recently, the incentive program in the support of improving fuel economy has also been widely implemented worldwide. Similar to the home appliances, the purpose of the incentive program in this sector is to create awareness and to encourage consumers to use and buy more efficient vehicles. The Incentive programs for the motor vehicles will act as a support to maximize the effectiveness of fuel economy standard and label. In addition to the reduction of vehicle fuel consumption, the program indirectly reduces the negative impact on the environment such as GHG emissions.

The fuel economy is a fuel consumption of vehicles per distance traveled. It is adopted as a way to evaluate the performance of a vehicle. Some countries, define appropriate policies that inhibit entering vehicles with more than maximum standards fuel consumption, to the market. Fuel economy standards can be implemented either mandatory or voluntary. A mandatory fuel economy standard is generally the most effective strategy for rapid improvement of the fuel economy of motor vehicles. While, the voluntary fuel economy standard that is implemented by negotiation between the government and manufacturers is the alternative option.

On the other hand, the fuel economy labels enable consumers to compare the energy efficiency of motor vehicles on a fair and equitable basis. The fuel economy label acts as an indicator that gives required information about the efficiency of the vehicle to the potential buyers. The fuel economy labels, through informing the consumers about the fuel efficiency will create competition among the manufacturers. Energy labels not only set a guideline of efficiency for the manufacturers, but also encourage them to improve their vehicles while keeping their cost low to win the market. Motor vehicles with the best energy rating and the most competitive prices are more likely to be sold in large numbers by introducing an appropriate energy label. While causing impact on energy, economy and the environment, the program is also creating market transformation on motor vehicle efficiency.

This paper aims to give a review on the international experiences of the incentive programs in supporting the fuel economy standards and labels for motor vehicles.

2. Definition and hierarchy of fuel economy standards and labels

Fuel economy standards and labels have been proven as the best policies to reduce energy consumption growth, and pollution in the transportation sector. It is also a popular strategy to educate consumers to use energy, efficiently. The hierarchy of fuel economy standards and labels which are proposed in this study are shown in Fig. 1.

2.1. Fuel economy standard

Fuel economy standard is an energy efficiency directive for motor vehicles in a certain country that prohibits marketing the vehicles with less than prescribed standard. The fuel economy standards commonly encompass the target limits on fuel consumption (maximum use of fuel or minimum efficiency level). These standards are different in stringency in terms of how the vehicle fuel economy or GHG emission levels are measured in the test procedure [24]. The fuel economy improvement policies have been introduced in the US, EU, Japan, Singapore, China, etc. The main purpose of implementing fuel economy standards for passenger cars is as follows:

(i) To prohibit inefficient motor vehicles from entering into the market in certain countries or regions.
(ii) To increase fuel economy standard and decrease the average emissions of newly registered cars.
(iii) To produce more efficient cars in the country through a combination of fuel economy standards and advance technologies.
(iv) To influence the local motor vehicles manufacturers to improve the fuel economy of the newly produced vehicles gradually.

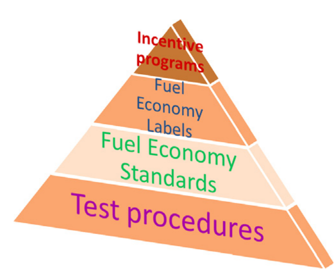


Fig. 1. Hierarchy of test procedure, fuel economy standards, fuel economy labels and incentive programs.

Table 1
Home categories and feature targeted for incentives program.

Category	Feature	Typical incentives
Structural	Attic insulation, windows, reflective roof, weatherization	Utility rebate programs, federal tax credit, manufacturer rebates
Mechanical	Duct sealing, HVAC service, HVAC replacement	Utility rebate programs, federal tax credit, manufacturer rebates
Appliances	Water heater, refrigerator, washer, dryer	Federal tax credit, loan programs, manufacturer rebates
Lighting	Lamps	Utility and manufacturer giveaways
Alternative Energy	Solar water heating and solar photovoltaic panels	Federal tax credit, state rebate program utility rebates, loan programs

(v) To encourage the manufacturers and importers to improve the fuel economy of the vehicle and to make sure that efficient vehicles are available in the market.

2.2. Fuel economy label

Fuel economy label is necessary to provide useful information for consumers. The effectiveness of fuel economy label depends upon supportive retail staff, advertisement and consumer awareness of the label. Therefore, it is important to create simple and comprehensible labels. Some of the fuel economy labels that are implemented around the world are presented in Figs. 2–4 [25–27].

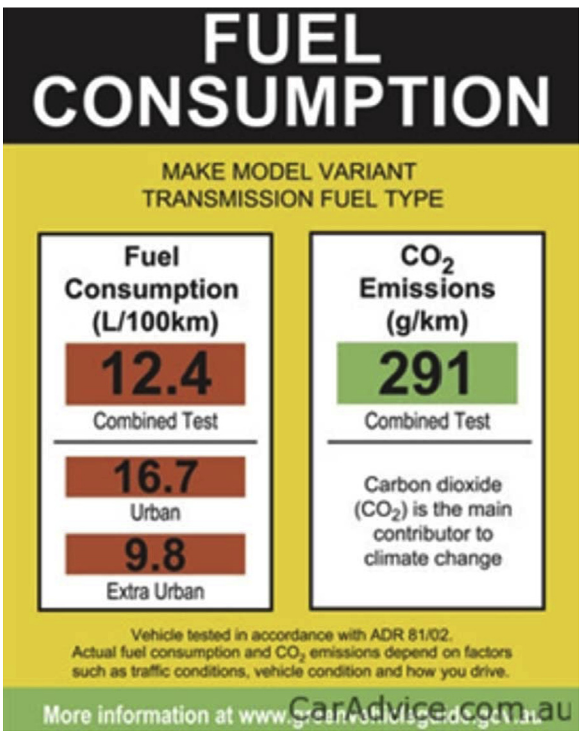


Fig. 2. Australian fuel economy label.

The manufacturers respond to both legislative requirements and customers' preferences. There are multiple benefits of implementing fuel economy labels, however, the most striking benefits of the program are as follows [28,29].

(i) To allow consumers to get more information about the efficiency level or fuel economy classification of the motor vehicles.
(ii) To increase awareness of fuel consumption and/or emissions, which consequently help the consumers to select the most efficient vehicles.
(iii) To make consumers aware of the fuel economy level that influences their purchasing decisions, this leads to a market transformation towards energy efficient vehicles.
(iv) To motivate manufacturers to produce motor vehicles with a better fuel economy level.
(v) To provide a pool of more efficient vehicles in the market by label grading mechanism.

3. Incentive program

An incentive program is a mechanism to increase the effectiveness of certain policies. Based on other countries' experiences, the implementation of the program in theory and formula level is not enough to encourage consumers. For effective results, one should understand and consider the culture and custom of a particular country or region [30]. Those countries introduce many types of taxation mechanisms to promote more fuel efficient vehicles as an incentive program. Some of the taxes are based on the volume of the engine while some others are based on CO_2 emission level, the age of the vehicle, and the mileage of a vehicle. This program introduces taxation for inefficient motor vehicles and use these taxes to give incentives to consumers who want to purchase more efficient motor vehicles [31].

3.1. Taxes

3.1.1. Fuel taxes

Fuel is a commodity that can be subsidized and taxed. In Malaysia the price of fuel is still under government's subsidization, however in many developed countries the tax is on the fuel price.

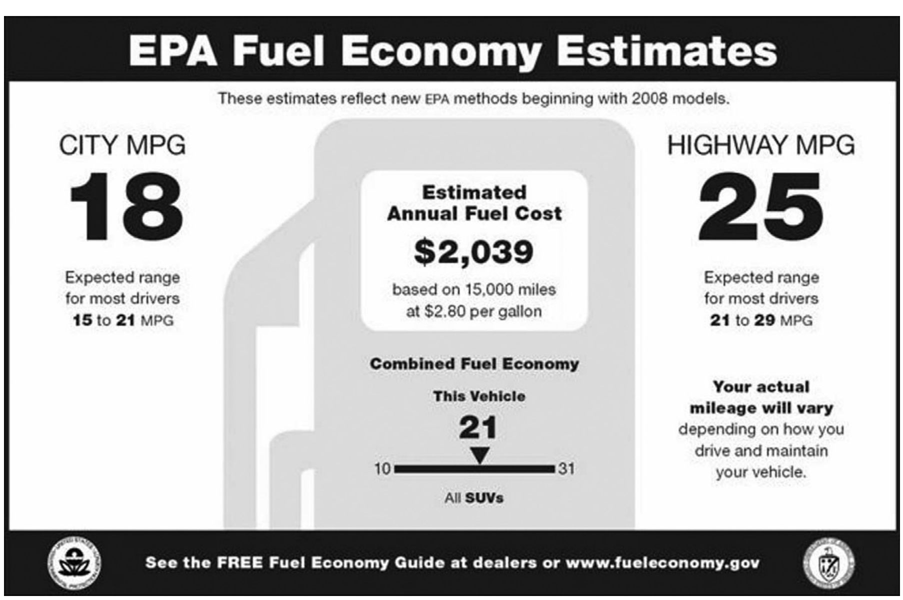


Fig. 3. The US fuel economy label.

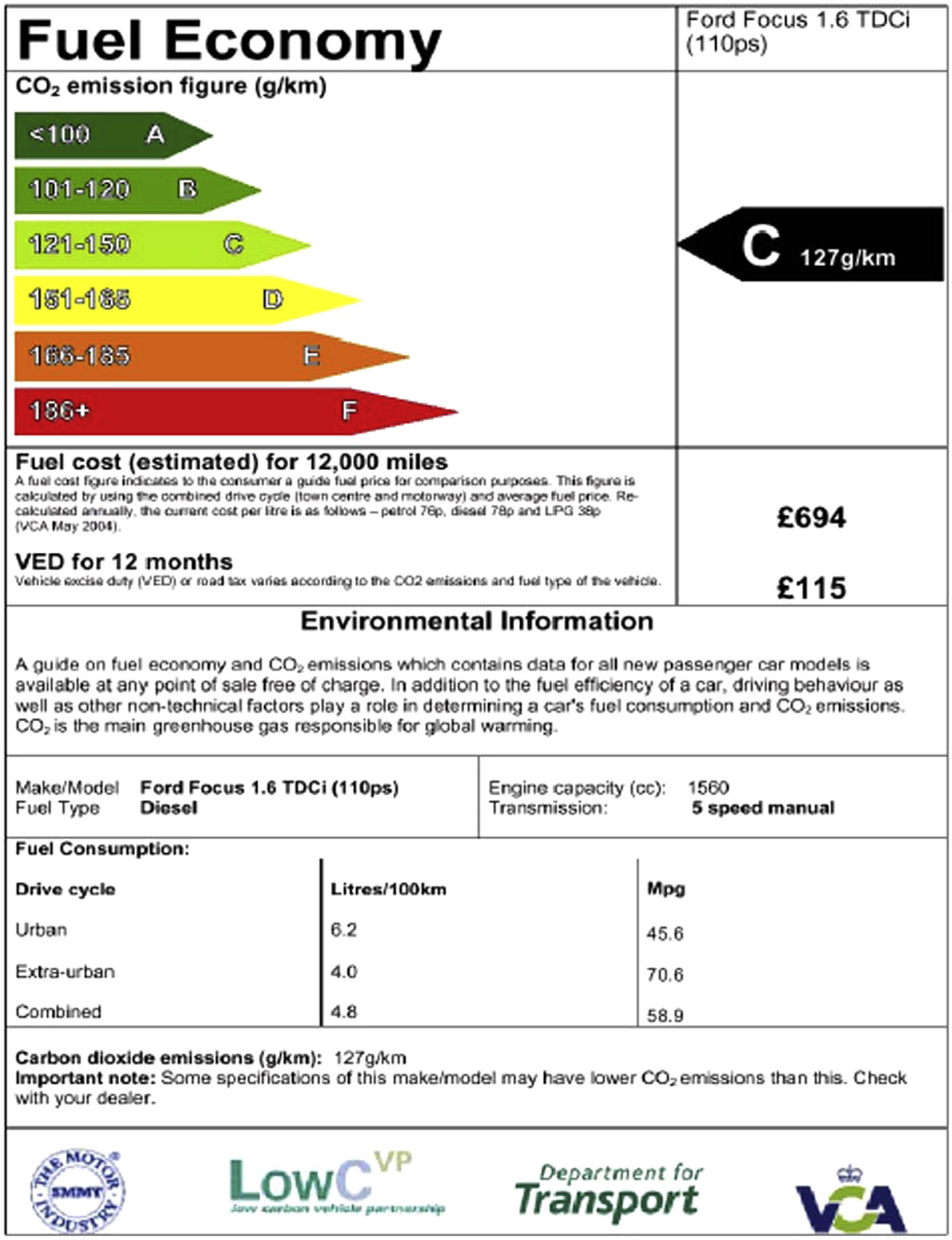


Fig. 4. UK fuel economy label.

In most of developed countries the fuel tax is implemented for transportation [32]. The fuel taxation has two important objectives: (i) to indirectly force people to use public transportation system instead of driving personal car and (ii) to improve quality of transport infrastructure by using the monetary collected from fuel taxes [33].

The fuel taxations are usually used by the government to maintain and develop transportation infrastructure, mitigate greenhouse gas emissions, and to improve health effect of transport related emissions. All of those emissions' taxation and fuel taxes together with energy efficiency policies such as fuel economy standards and labeling, must ensure to reduce the emissions in the country [34]. The amount of fuel taxes in each country differs based on the necessity and the condition of that particular country, and there is no simple formula for setting these taxes.

The taxes are dependent to mobility, environment, society, economy, and politics of a certain country. As an example, the fuel tax level in the United States is lower than some European countries. The fleet average fuel consumption target has been used in the United States for improving fuel economy of the motor vehicles, while in Europe, the higher fuel process has been implemented for this purpose. The European counterpart has accomplished more benefits from the program in improving fuel economy and emission of motor vehicles [35]. The comparisons of fuel tax around the world are presented in Figs. 5–8 [36].

Actually, fuel taxes can provide incentives to purchase more fuel efficient cars. However, many countries currently apply low fuel tax rates or even subsidize the fuel, which is counter-productive from an energy efficiency point of view [34]. Although fuel taxation has purposed to encourage the purchase of more efficient cars, its effect has been offset by some factors in some countries. One of the most contributing factors is an increment in the share of diesel vehicles. The explanation on the increment of diesel vehicles is that the fuel tax on diesel oil is much less than on gasoline. Therefore, it is very important to study the effects of fuel taxation on consumers' decision in vehicle selection. However, based on the offered literature, there are no

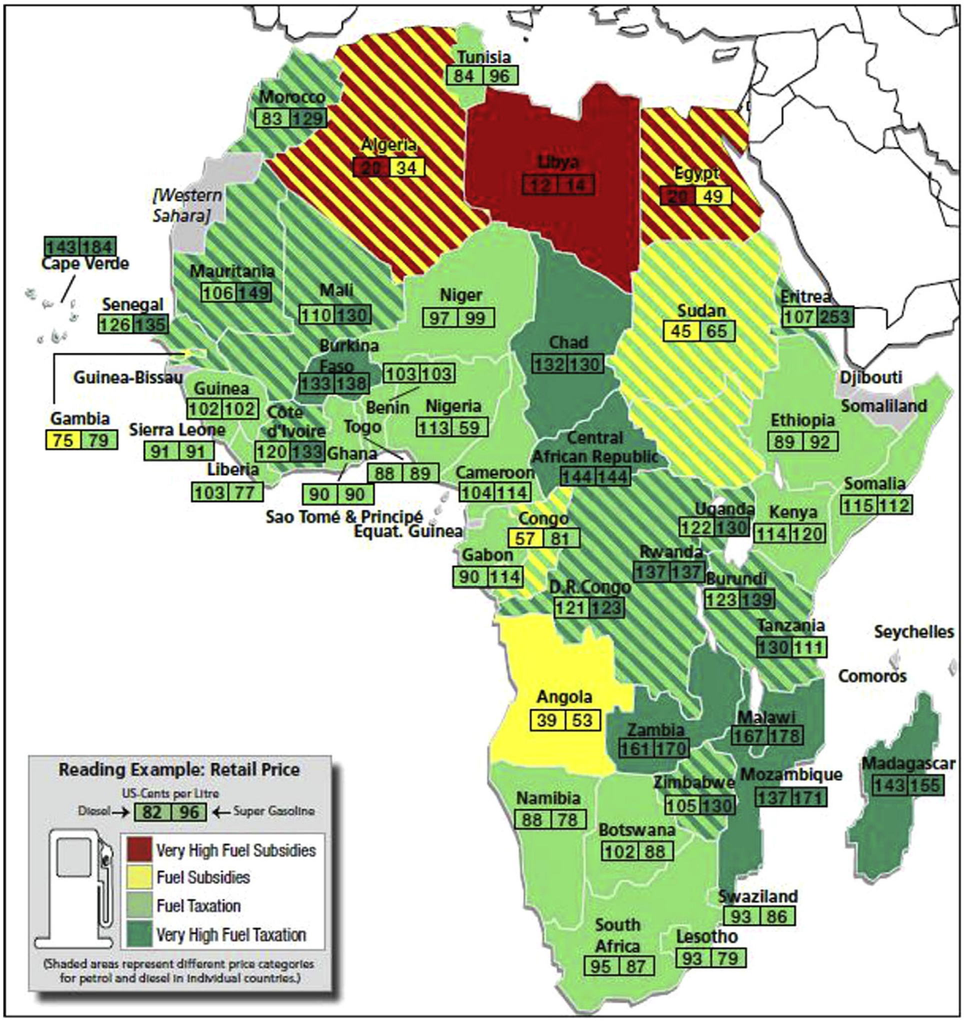


Fig. 5. Retail fuel price in Africa.

previous studies about the effect of fuel taxation on the vehicle selection [37].

The money from fuel taxation is used to improve transport infrastructure such as the quality of the road, public transportation system, and to support the programs related to transport sustainability. The transportation becomes more efficient when the fuel economy standards become more stringent [34].

3.1.2. *Gas guzzler*

The United States authority implements gas guzzler taxes for new cars that cannot achieve fuel economy standard [38]. This is considered as a policy that helps to pay an extra cost for more efficient vehicles, which considered as fee bates. Gas guzzle was introduced as an energy tax act in 1978 to encourage manufacturers to produce vehicles with higher fuel economy. Only passenger cars are affected by this tax while trucks, minivans, and sport utility vehicles (SUV) are not included in the program. This is because these vehicle types were not widely available at that time and they were rarely used for non-commercial purposes [39].

Meanwhile, for gas guzzler tax, the fuel economy is based on a combined cycle of city and highway and to calculate the tax, the procedure used is provided by United States Environmental Protection Agency (EPA) is followed. For developing the fuel economy label, the manufacturers and EPA use the same procedure for testing fuel economy of new vehicles. However, the methods of calculation for the fuel economy label and the tax are different; therefore, the value of fuel economy is different for these two tests. This is due to an adjustment factor on fuel economy value derived from experimental test results that is used only for the fuel economy label grade and not for the tax. The purpose of this adjustment is to consider the difference between on the road and laboratory testing condition [39].

The gas guzzler tax was introduced for the first time in 1980, and then reviewed in 1991. It only affected the passenger cars that have fuel economy less than 22.5 mpg. Due to this program, the share of vehicle purchase by consumer has decreased by $\pm 5\%$. Also the sale revenues have increased due to the value added to the vehicles by improving technology that resulted in improving fuel economy of the cars [40]. As a consequence, the fuel's sale has decreased because of the increment in fuel economy of the vehicles, assuming that consumer uses the same driving pattern [41].

The taxes for the vehicles are collected directly from manufacturers or importers by the Internal Revenue Service (IRS). The amount of the collected tax is affixed at the windscreen of the vehicles at the purchasing time. The tax will be paid by the importer or manufacturer for the vehicles with fuel consumption more than the minimum fuel economy standards, 22.5 mpg. Gas guzzler tax rate is shown in Table 2 [39].

The Gas Guzzler Tax has led to American passenger cars' downsizing. In addition, the combination of the tax in the early 1980s substantially removed the full-size American car from the market.

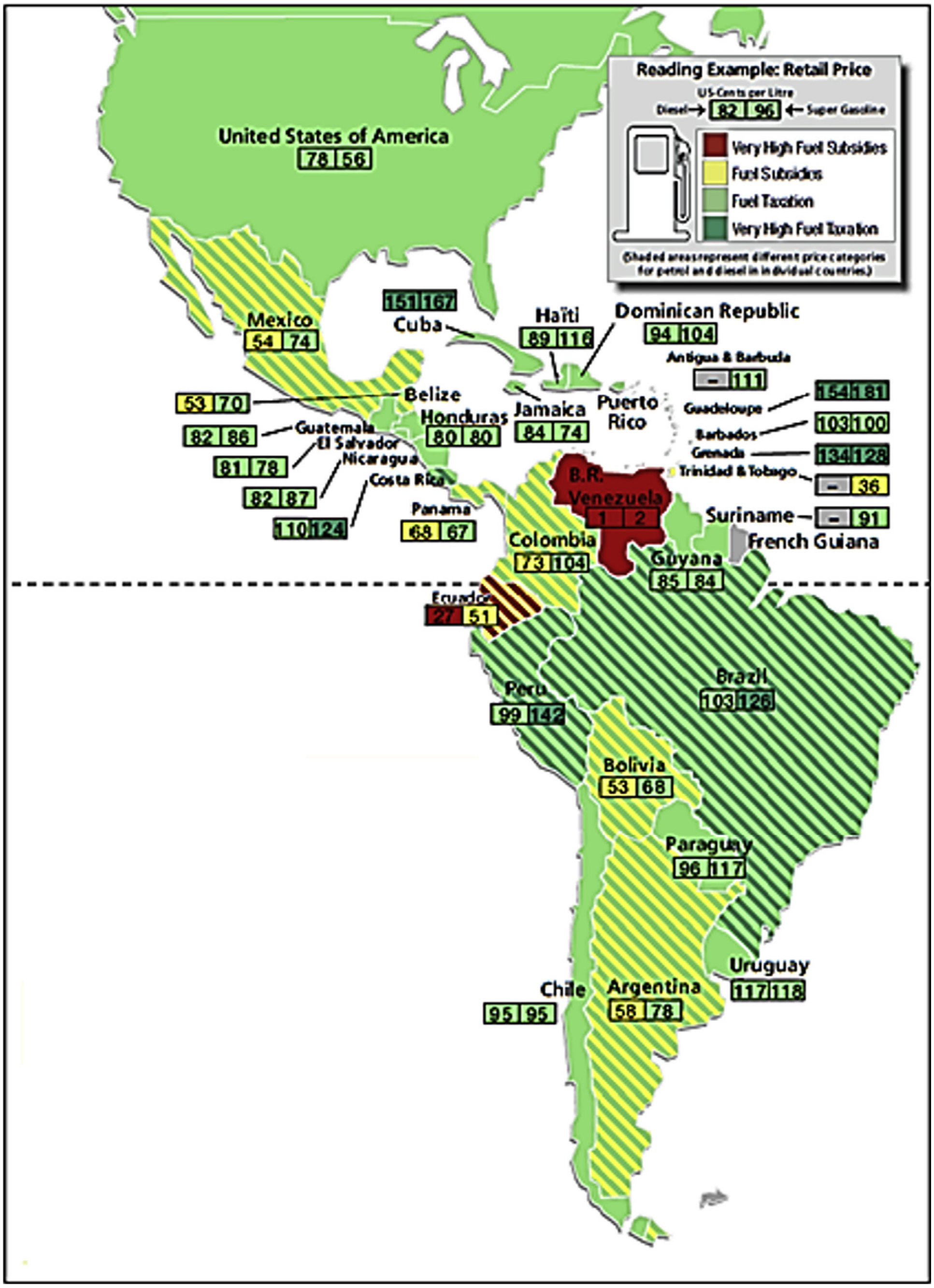


Fig. 6. Retail fuel price in America.

Coincidentally, it encouraged the consumers to purchase cars such as SUV due to the absence of the tax in mid-size and full-size SUV [41].

Critics of the Gas Guzzler Tax is that the increased fuel economy of the US passenger car fleet observed since 1978 must be considered in the context of the increased market share of mid-size and full-size SUVs [41]. The theories and analysis of ‘Gas Guzzler Tax’ in the US have been discussed intensively in the Refs. [40,42–53].

3.1.3. *Ad valorem tax based on CO_2*

An ad valorem emission tax rate based on CO_2 emissions has been developed in South Africa to reduce road transport emissions. The Road Traffic Act of 1996 with its relevant regulations allows governments to enforce certain road transport fees. Revenue generation was the main reason behind the environmental-related taxes, while environment protection was bonus to such taxes [54].

In the 2010 budget, the government recommended the 2009 Ad Valorem CO_2 tax on emission for new passenger cars to be transformed to the Flat Rate CO_2 taxation. This is an additional taxation policy based on CO_2 emission. The taxation was based on certification of CO_2 emissions of new passenger car for each g/km, in addition to the current Ad Valorem luxury tax on new vehicles [54]. However, without clean fuels policy, the policy on lower CO_2 emission vehicles will not work well. The current ad valorem luxury tax, ad valorem emission tax rates and CO_2 vehicle emissions tax are tabulated in Tables 3–5 respectively [34,55].

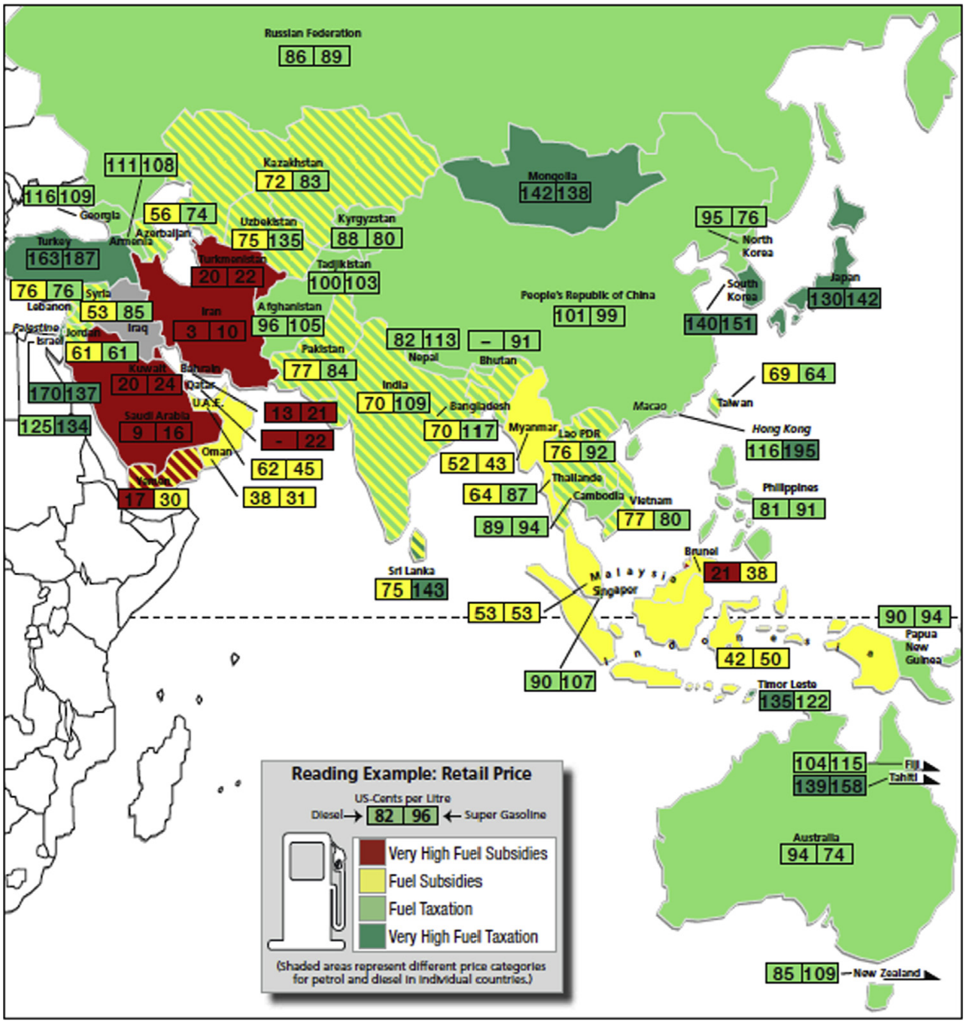


Fig. 7. Retail fuel price in Asia, Australia, and Pacific.

3.1.4. Volume based taxation to encourage smaller engine

The volume based taxation to encourage smaller engine has been implemented in China, India and Mexico which will be discussed in the following section.

China: The motor vehicle taxation was recently revised in this country. The purpose is to strengthen incentive programs for the vehicles sale and purchase for smaller engines. There are two components of taxation namely (a) automakers excise tax levied and (b) consumers sales tax levied. The tax rates implementation is based on engine displacement [34].

India: The 2012 budget that was presented in parliament has a significant impact on transportation sector of the country. The excise duty on vehicles with small length and petrol engine capacity less than 1.2 L or diesel engine with a capacity less than 1.5 L, will fall under the general excise duty increment, from 10% to 12%. The excise duty for larger vehicles with more than 4 m length and petrol engine capacity over 1.2 L or diesel engine capacity over 1.5 L has been increased from 22% to 24%. Furthermore, for mixed group vehicles like MPVs and SUVs, the excise duty has been increased from 22%+INR 15,000 to a flat 27%. Whereas all Completely Built Unit (CBU) imported cars costing over $40,000 and an increasing of the excise duty, from 60% to 75% [56].

Mexico: The owners of the car in this country have to pay higher taxes for larger and older vehicles but they get exemptions from taxes if they drive hybrids. This was affected by a new bill submitted to the Mexican Congress by the Partido Verde Ecologista, or Mexican Green Party. The proposal asks for exemptions on 2009 hybrid vehicles, also they would be exempted from the general 15% consumption tax. The reform, if approved by Congress, would decisively promote green technologies in motor vehicles and could reduce domestic consumption of oil resources [34].

3.2. Fee bates and rebates

A fee bate is an incentive policy that encourages the continuous improvement in automobile fuel economy and emissions by providing incentives for manufacturers who build more efficient vehicles, and rewarding consumers who purchase more efficient vehicles. According to David L. Greene, Professor of Economics at the University of Tennessee, fee bates are a fiscal policy for encouraging car buyers to prefer more efficient, lower emission vehicles, and manufacturers to produce them. The concept was pioneered in the 1970s by Koomey and Rosenfeld from Lawrence Berkeley National Laboratory, and currently it is finding interest around the world [48,57–63].

The policy gives inefficient vehicles a surcharge, and efficient vehicles are granted a rebate. The fees from the inefficient vehicles is used as a rebate for the efficient vehicles [64]. Today more than 16 European countries have some forms of CO_2 or fuel consumption tax on the light duty vehicles [57,65–70]:

In the countries that have implemented this policy, it has proven that, fee bate programs can be extremely useful in supporting the widespread adoption of the efficient vehicle technologies. If the program can be developed and implemented properly, the government subsidies can speed up the emergence of

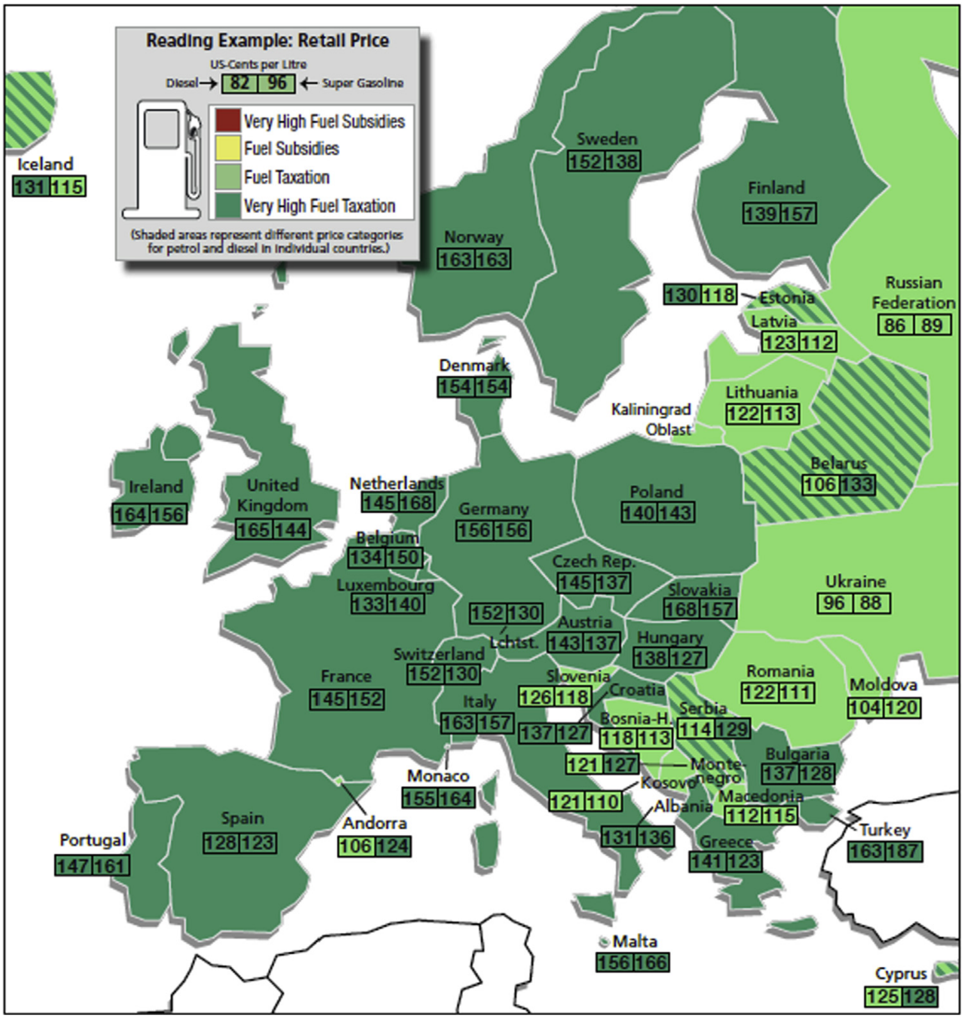


Fig. 8. Retail fuel price in Europe.

Table 2
Minimum fuel economy level.

Combined fuel economy	Amount
At least 22.5 mpg	No tax
At least 21.5, but less than 22.5 mpg	$1000
At least 20.5, but less than 21.5 mpg	$1300
At least 19.5, but less than 20.5 mpg	$1700
At least 18.5, but less than 19.5 mpg	$2100
At least 17.5, but less than 18.5 mpg	$2600
At least 16.5, but less than 17.5 mpg	$3000
At least 15.5, but less than 16.5 mpg	$3700
At least 14.5, but less than 15.5 mpg	$4500
At least 13.5, but less than 14.5 mpg	$5400
At least 12.5, but less than 13.5 mpg	$6400
Less than 12.5 mpg	$7700

Table 3
Ad valorem "luxury" excise duty rate.

Retail price	Current rate (%)	Proposed rate (%)
R 50,000	0.5	0.0
R 100,000	1.7	0.6
R 150,000	2.9	1.4
R 200,000	4.1	2.2
R 300,000	6.5	3.8
R 400,000	8.9	5.4
R 500,000	11.3	7.0
R 600,000	13.7	8.6
R 800,000	18.5	11.8
R 864,000	20.0	12.8
R 1,000,000	20.0	15.0
R 1,312,500	20.0	20.0

new and clean technologies for vehicles. This helps to ensure that the economics scale are achieved, so that efficient vehicles in the future are affordable to the general public without intervention by authority in the market [57]. Deep discussion and analysis related to fee bates program can be found in Refs. [40,42,48,49,52,61,63,71–86].

The rate and the pivot point are critical components of the fee bate system, because they determine how much the rebate or surcharge will be, and which vehicles will receive a rebate or a surcharge. The authority should consider every aspect when calculating the rate of the fee bates policy because it has significant fiscal impact. The rate should allow consumers to understand the life cycle analysis of their vehicles. Meanwhile, pivot point is the point that differentiates between efficient and inefficient vehicles. The fee bates formulas are given in Eqs. (1) and (2) [64].

$$\text{Feebate} = \text{Rate}\left(\frac{1}{pp} - \frac{1}{fe}\right) \quad (1)$$

$$PP = C\frac{\sum(1/fe)(\text{sales volume})}{\text{sales volume}} \quad (2)$$

where Febate: (+) rebate (−) surcharge ($), Rate is the rate of a gallon of fuel ($/gpm*), *PP* is the pivot point (mpg), *fe* is the fuel economy of a given vehicle (mpg), *C* is the constant and *gpm= 1/mpg gallons per mile.

Canada: The country has implemented a fee bate structure consisted of two programs namely Eco Auto and Green Levy. The Eco Auto Rebate Program was included in the federal Budget 2007. The Eco Auto rebate policy offers rebates from C$1000 to C$2000 to people who purchase or commit a long-term lease for a fuel-efficient vehicle while, Green Levy program levies a tax on fuel-inefficient vehicles from C$1000 to C$4000. The Eco Auto rebate was applied to cars that have fuel economy of 6.5 L/100 km or better, and new light trucks consuming 8.3 L/100 km or better. Moreover, the program has also introduced a rebate for flex-fuel vehicles with E85 consumption ratings of at least 13 L/100 km [87]. However, the program has been abolished on March 31, 2009. In that period, the Eco Auto Rebate Program has received over 182,300 applications and issued over 169,800 rebates totaling C $191.2 million [88]. The Green Levy imposes a tax that starts at C $1000 for vehicles which use between 13 L/100 km and 14 L/100 km. It proceeds in $1000 steps for every litre that increase in consumption up to 16 L/100 km or more [87]. At the end of Eco Auto rebates program, The Ontario government has announced ambitious rebate programs from C$4000 to C$10,000 to consumers that purchase new, plug-in, hybrid electric, or battery electric vehicles after July 1, 2010. The rebate is offered to the first 10,000 customers in order to achieve the goal of the province to have 5% share of the electrically powered vehicles by 2020 and to reduce emissions of greenhouse gases 6% from 1990 levels by 2014 [89–92].

Table 4
Ad valorem emissions tax rate.

CO_2 (g/km)	CO_2 tax rate (%)
100	0.0
110	0.0
120	0.0
140	1.3
160	2.7
180	4.0
200	5.3
220	6.7
240	8.0
260	9.3
280	10.7
300	12.0

Chile: The fee-bate scheme system is not implemented yet in Chile. However, the Centro Mario Molina Chile presented the proposal for fee-bate program to the government in July 2011 [93,94]. The implementation of the fee-bate program in this country is expected in the near future.

China: This country will spend at least 12 billion Yuan ($1.76 billion) to subsidize smaller, fuel efficient cars by 2012 as a part of plan to decrease fuel emissions in the country which has the world's largest number of vehicles. About 3000 Yuan will be offered for small cars with 1.6 L engines or smaller that consume 20% less fuel than current standards. According to the Chinese National Development and Reform Commission, 71 of hybrid, electric and fuel efficient models would be eligible for the subsidy in 2012. According to the National Development and Reform Commission it is estimated that 4 million of such vehicles will be covered for the same year. Subsidies will also be given to purchaser in five selected cities namely, Changchun, Hangzhou, Hefei, Shanghai and Shenzhen who buy electric vehicles and plug-in hybrid models. They would receive up to 50,000 Yuan ($7320) in subsidies. The subsidy of 60,000 Yuan will also be given to those who purchase fully electric vehicles. The subsidies will be forwarded to the automakers that lower the sticker price of the vehicles in car showrooms instead of handing out to the consumer. From this program, it is expected that the subsidies will have a large impact on the sale of green cars and will give consumers an opportunity to purchase an electric or hybrid vehicle at a subsidized price. Moreover, the government will fund the construction of recharge points and battery recovery networks in the pilot cities [95].

France: There is a program to reduce vehicles' emissions in this country called the Bonus-Malus program. This is a part of France comprehensive environmental framework known as the Grenelle Program. It paid a bonus to buyers that were introduced in 2009 for purchasing cars emitting a maximum of 130 g of carbon dioxide per km (209 g per mile). The bonus ranged from $255 to $6365 depending on vehicle emissions levels. In 2010, the bonus was awarded to vehicles with the emission of maximum 125 g per km and bonuses were reduced [57].

United Kingdom: On April 16, 2009, UK government announced ultralow carbon vehicle policy. The Secretary of State for Transport and Business jointly announced this strategy that includes a £250 million fund, for the period from 2009 to 2014.This is an incentive

Table 5
CO_2 vehicle emissions tax.

CO_2 emission (g/km)	Average CO_2 emission (g/km)	Number of vehicle (12 months)	% of vehicle in 12 months	CO_2 emission above threshold; g/km > 120	Tax at 75 per g/km	Average price	Average tax rate (%)
Below 120	110	342	0.2	–	–	177,000	0.0
	120	493	0.2	–	–	170,000	0.0
	130	10,904	4.9	10	750	121,000	0.6
	140	15,856	7.2	20	1500	164,000	0.9
	150	20,794	9.4	30	2250	169,000	1.3
	160	21,694	9.8	40	3000	181,000	1.7
	170	33,552	15.2	50	3750	166,000	2.3
	180	46,664	21.1	60	4500	164,000	2.7
	190	24,224	11.0	70	5250	244,000	2.2
	200	10,183	4.6	80	8000	193,000	2.0
	250	22,928	10.4	130	9750	391,000	2.5
	300	8083	3.7	180	13,500	552,000	2.4
	350	4161	1.9	230	17,250	551,000	3.1
	400	778	0.4	280	21,000	947,000	2.2
Above 400	450	25	0.01	330	24,750	606,000	4.1
Average/total	178	220,681	100	58	4350	227,000	1.9

for consumers to stimulate the take-up of electric and plug-in-hybrid cars amounted from £2000 to £5000. However, the eligible cars for this policy must satisfy strict standards, CO_2 emissions standard and should be designed for the mass production [57].

3.3. Buyback programs

The government introduced this program by providing budget to promote and replace old vehicles with modern ones that are more efficient. The program was implemented with the objectives of stimulating the automobile industry and removing inefficient high emission vehicles from the road transport. These kinds of programs have been widely used by some countries to speed up the retirement of older inefficient vehicles. However, it is usually motivated by economic reasons, with emissions and efficiency considerations as secondary importance. The programs provide monetary or other incentives for owners that voluntarily retire their older vehicles and vehicles with more emissions. Incentives may be given directly to the owner, may be it takes the form of tax benefits, or may be paid directly to the newer vehicles vendor [96].

The buyback programs' balance of costs and benefits are not straightforward. This is due to all pollutants are not closely related to vehicle age. Moreover, increasing fuel economy will even lead to an increase mileage traveled of the vehicle. In addition, if vehicles are not properly retired (e.g. injection of the engine block with sodium silicate to prevent further recirculation of vehicles or selling to developing countries, as in the US case), then the vehicle could potentially come back into use, through the second hand car trade [96]. And this case is true in South East Asia. The buyback programs in some selected countries are discussed below.

Australia: The government encourages the buyers to trade older vehicles with new ones which are more efficient. A tax break of 30–50% discount will be given to the buyers. It will reduce the cost of new vehicles. This program was introduced between 13 December 2008 and 31 December 2009 [97]. The program was a part of the government's $42 billion Nation Building and Jobs Plan to create up to 90,000 jobs in Australia. For this, $2.7 billion has already been spent by giving beneficial tax incentives to increase vehicles' sales. However, this program did not carry any special efficiency obligation when purchasing a new vehicle [98].

California: The buyback program is implemented by the Bureau of Automotive Repair (BAR) of California. It offers $1000 per vehicle and $1500 for low-income buyers. The program's objective is to reduce the fleet's emissions by accelerating the replacement of existing inefficient vehicles in the market and subsequent replacement with new vehicles that have a less emission. Decreasing the emission of existing vehicles is a part of California's State Implementation Plan, which frameworks the State's policy for achieving healthy air quality standards. The California sticker for buyback program is presented in Fig. 9 [99].

China: The buyback program in this country was enacted in June 2009 and scheduled to end in March 2010. Nevertheless, the authority extended the buyback incentive program to end in 2010 to encourage buyers to purchase new efficient vehicles. In this program, consumers eligible for a subsidy of 5000 Yuan (US $732) and 4000 Yuan (US $586) who trade-in light trucks and mini trucks, respectively [96].

France: The scrap page program was introduced on January 19, 2009. The various incentive programs were started with €1000 for the vehicles with a maximum emission of 160 g/km. In this program, the old car is necessary to be older than 10 years and the new car would necessary to achieve a specific standard CO_2 emission. For cars with CO_2 emission less than 60 g/km, the maximum premium of €5000 will be granted. This program costs the French government US $554 million [96].

Italy: A scrap page program was implemented in this country since January 1, 2007 until December 31, 2008. The program granted €700 plus as a tax rebate for a new efficient car. A new scrap page program was implemented in 2009. New cars must fulfill a minimum standard of Euro 4 and must satisfy CO_2 emission maximum of 130 g/km for diesel or 140 g/km for other fuels. The scrapping incentive is €1500 but it can be combined with the purchase incentive of €1500 for a new car running on electricity, hydrogen or CNG. This will increase to €3000 if the CO_2 emission is exactly 120 g/km, and to €3500 if it is less than 120 g/km for a new vehicle. By Using the LPG, the purchase incentive is €1500 and it will increase to €2000 if the emission of the car is less than 120 g/km. This can also be combined with the scrapping incentive [100].

Russia: There is not much information accessible in the literature about buyback program in Russia. One of the literature



Fig. 9. California's buyback program.



Fig. 10. Car allowance rebate system in the US.

indicated that a national buyback program was introduced in 2010. The program has been implemented successfully in this country; however, it is not very clear how the program takes place. Nevertheless, the authority is enthusiastic to reduce the environmental impact, specifically from transportation sector [96].

Turkey: This country has implemented the vehicle buyback/scrap page program since 2003. The result of the program was a CO_2 emissions' reduction by 4.9% in these 2 years period. However, there is no information about the further development of the program at the moment [96].

United States: The Car Allowance Rebate System (CARS) is about $3 billion from Federal Government's programs to help U.S. citizens to buy new and more efficient vehicles. The program officially began on July 1, 2009 and the claim was processed until July 24, and ended on August 24, 2009 [101–103]. The initial $1 billion allocated for the program was discharged on July 30, 2009, before the expected deadline, on November 1, 2009, as the demand was very high. In response, Congress approved an additional $2 billion for the program [104–106]. Department of Transport reported on August 26, 2009, that the program causing 690,114 dealer plans to file the application requesting the total value of $287.7 million in rebates. At the end of the program, Toyota accounted for 19.4% of sales revenue, followed by General Motors of 17.6%, Ford 14.4%, Honda 13.0%, Nissan 8.7%. Toyota Corolla was named the best-selling brand. In addition, the Ford Company also reported that the average fuel economy was 15.8 mpg. While the new model to replace them having fuel economy improvement by 58% to 24.9 mpg. The researchers at the University of Michigan do not take into account the fuel economy of the average baseline, in the study of the impact program assessment procedures. This is because the purchase of a vehicle with higher fuel economy has been the trend, due to the high gasoline prices in 2007 and 2008, and the crisis economy in 2008. The study found that the program increased fuel economy of the vehicles by 0.6 mpg and 0.7 mpg purchased in July and August 2009 respectively. The car allowance rebate system in the United States is presented in Fig. 10 [96].

United Kingdom: Britain has launched a buyback incentive plan in the 2009 budget, and it closed on March 31, 2010. Old cars with registration date on or before July 31, 1999 will be removed from the street and the owner received a £2000 cash reward. The government and the car industry share the funding by a half for each party. The plan is limited to £300 million, benefiting approximately 300,000 customers. Many dealers participate in the program to provide more than the recommended £1000, up to £2000 or even £3000 [95–97]. On September 28, 2009, it was confirmed that this program can be expanded further to include vehicles with the registration date on February 29, 2000 onward [107].

Japan: On 1 April 2009, Japan launched a plan up to 250,000 yen (U.S. $2500) to trade 13 years old or older vehicles with new environmentally friendly and fuel-efficient automobile transactions, in accordance with the performance standards set by the Government until March 31, 2010. The small car purchase rebate is about 125,000 yen (about U.S. $1250), which has a preferential tax treatment. The specifications are prescribed by the law, which is based on the engine displacement size and power constraints. The Japanese government also allocated $3.7 billion for the program plan that includes tax cuts gasoline–electric hybrid vehicles and low-emission cars and trucks [108,109].

Germany: So far the largest program in this country is page schemes. Every car owner with the vehicle's more than 9 years old, entitled to buy a new car with premium scrap yard for $2500 ($3320). The program launched on January 13, 2009. It was limited to a maximum of 600,000 vehicles with the budget of €15 billion. But the booming car market with an unexpected increase of 40% sales (March 2009 compared to March 2008) made the program run too short to offer more than a short called stimulus. On March 25, 2009, the government decided to continue the scheme of the scrap page until the end of the year [110–112].

Other countries: Besides the countries mentioned above, there are other countries that enacted the scrap page program such as Austria, Canada, Ireland, Luxembourg, Netherlands, Norway, Portugal, Romania, Slovakia, and Spain which can be referred in Refs. [113,114].

Table 6
Penalties tax structure in China.

Category by engine displacement (L)	Tax rate prior to 4/1/2006 (%)	Tax rate 4/1/2006–8/31/2008 (%)	Tax rate beginning 9/1/2008 (%)
< 1.0	3	3	1
1.0–1.5	5	3	3
1.5–2.0	5	5	5
2.0–2.5	8	9	9
2.5–3.0	8	12	12
3.0–4.0	8	15	25
4.0 and greater	8	20	40

3.4. Penalties

Penalties for failure to meet the fuel economy or fuel consumption standards are developed to assess and fine automakers. The penalties programs and procedures in certain countries are discussed below:

China: The country has put the tax structure, punishment for the large engine cars, and encouragement for purchasing the fuel-efficient cars. The structure of the tax schedule in China is presented in Table 6 [95].

European Union: CO_2 regulation for vehicles set punishment mechanism based on the amount of excess emission. If the manufacturer fails to achieve its objectives in a given calendar year, it will be required to pay an additional premium of emissions. The emission premium was designed for the manufacturers to pay the emissions emit for each g/km of the average cars sold in that year which are above the target. The premium rises from €20 per g/km in 2012 to €35 in 2013, €60 in 2014, and €95 in 2015 and more [115].

Japan: To promote energy conservation and to reduce carbon dioxide emissions in Japan, the "Top Runner" energy efficiency program was launched in 1999 to increase automobile fuel efficiency. The fuel economy target was based on weight class. The car manufacturers permitted to collect accumulated credits in one weight class to use in different weight classes with certain restrictions. The minimal penalties will be applied if targets are not achieved. The program to improve the standards' effectiveness is enhanced by the highly progressive tax imposed on gross vehicle weight and engine displacement car that were purchased and registered [116].

United States: The manufacturers in the U.S. who fail to meet CAFE standards are imposed penalty of $5.50 for each tenth of a mpg of the target value times the total number of vehicles in a given model year. From 1983 to 2004, car manufacturers paid a civil penalty of more than $618 million [116].

3.5. Registration fees

Registration fees that are assessed per year or every 2 years, are used to generate revenue, which can be used in various ways. The registration fee programs in the certain countries are discussed below.

Brazil: Processing the registration fee are handled by the city authority in Brazil, but the registration plates are standardized for the entire country. Brazil has used this system since 1990, which is a form of ABC1234 with the dot between the letters and numbers. The combination cannot be transferred to another vehicle [117].

Chile: In this country, the vehicle registration fee is inversely proportional to the age of the vehicle, and the effect of rewarding ownership of the old vehicles. The main challenge is to change the structure to an equity-based, since poorer people tend to have older cars. Furthermore, the current car sales tax system does not encourage the use of efficient vehicles [117].

European Union: The general format for the EU Council Regulation (EC) No. 2411/98 was effective on November 3, 1998, and put into force on November 11, 1998. It was based on registration plates in several introduced member states. On July 5, 2005, the European Commission submitted a proposal to the directive that required member states to restructure their passenger car taxation systems [117].

United States: In this country, the registration fee is managed by the state government. The systems are very different from one state to another. In Maine, the registration fee is $35, and a vanity place will cost for $25. District of Columbia charges $25 for 5 years and $35 for 10 years. Idaho charges the price of $36–$60, according to the age of the vehicle and the residence county. In Iowa, the annual vehicle registration fee is based on vehicles' weight, price and age. The registration fee is at least $50, if it has a title and it has registered after January 1, 2009. The registration fee in Kentucky is $25. In Maryland, the registration fee for 2 years is $128 for the vehicles under £3700, where for the vehicles over £3700, the costs is $180 for 2 years. Mississippi renewal cost is $20, while the North Carolina's registration fee is $28, with the title fee of $40. In Ohio, vehicle registration fee is $34.50 with an increment of $50 for the personalized plate. The Rhode Island has a $30 annual registration fee with a $1.5 surcharge, and the biannual fee is $61.50. This is for the vehicles that do not exceed £4000. The vehicles with the weight more than 4000 pounds have a higher cost. In the State of South Carolina, the registration fee is $24, which renews every 2 years. Vermont has petrol and diesel registration fees of $65 or $27 per year respectively and 2-year registration fees of $122 for gasoline and $50 for diesel. Washington will charge $25 per year for vehicle registration [117].

3.6. Investment in research and development

To ensure that the newest and the cleanest technology is developed within a reasonable period, additional help is necessary for manufacturers to start-up and overcome market restrictions. For this purpose, research and development (R&D) expenditure is essential. Although the automotive businesses invest capital in R&D, sometimes the government should enter into a cooperative agreement to help this activity financially. The investments in R&D programs in the certain countries are discussed below.

European Union: Green Car Initiative is a part of the European economic recovery plan, designed to strengthen innovation in the automotive sector and to focus on environmental progress with the allocation of €5 billion million (U.S. $6.7 billion) through a public–private partnership. The European Clean Transport Facility initiates the strategy through the European Investment Bank to provide financial support for the project. The European Green Car Initiative aims to work towards a breakthrough to encourage the use of renewable energy and pollution-free energy sources for the transportation sector. The Initiative covers passenger cars, trucks, buses, other related transportation systems, intelligent infrastructure, and the availability of refueling stations for alternative fuel, and charging infrastructure for electric vehicles. The funds will be spread over 4 years. The 20% of the total grant comes from the EU's Seventh Framework Program for R&D funding. It includes €500 million that will be funded by the industry. The remaining €4 billion is from EIB loan for individual projects from manufacturers and suppliers [118].

India: Tata Nano has become the center of attention due to the booming Indian automotive market that concentrated on the cheap and small car projects. Bajaj which is a leading two-wheeler maker and Renault, have a joint project to create ultra-cheap cars with the goal of achieving the significant amount of fuel economy of Nano. REVA electric car manufacturer in India licensed the technology to GM by the end of 2010 to sell an electric version of the Spark models. In April 2010, Toyota launched the

Prius hybrid car in the country, even though the demand for the car is expected to remain very low due to the high import tariffs. Several sport utility vehicles, especially the production of Mahindra Company, is deploying start–stop system. In addition to the considerations of cost and efficiency, manufacturers must address a new generation of ultra-lightweight car and compact car with the standard safety. Despite the increased penetration into the emerging markets, electric vehicles are still serious obstacles to overcome if they are widely adopted. The most important constraint is the price of the electric cars. For example, the Chevrolet Volt is expected to cost more than $40,000. Another serious constraint is the supply of electricity, as many developing countries still experiencing widespread power outages or inconsistent supply [118].

Turkey: In this country, through the 2002 National Research and Technology Foresight Program (Vision 2023 plan), the fuel cell for transportation, stationary and portable applications has been determined as a research area in the national agenda [118].

United States: In January 2003, the government announced a 5-year budget of $1.2 billion hydrogen fuel initiative. This was to perform research and development (R&D) and demonstration of hydrogen fuel cell as a substitute for gasoline engines. The program was developed under the leadership of the U.S. Department of Energy (DOE). The purpose of the program is to develop the technology by the year 2015, and to make hydrogen-powered car available for the consumers by 2020. In addition, the EPA provides funds to do a comprehensive research on the development of the state-of-the-art experimental techniques and numerical simulation applications focusing on new cutting-edge engine technologies. This effort is a part of the Advanced Vehicle Program to develop advanced combustion systems [118].

3.7. Incentives for the used alternative fuel

The proponents see alternative fuels and advanced technology vehicles as a combination to improve urban air quality, reduce dependency on foreign oil, and to reduce the greenhouse gas emissions. However, the main obstacle preventing the widespread use of alternative fuels and technologies is related to economics constrains. Because of these constraints and their potential benefits, therefore there is continued congressional interest to provide incentives and support for the development and commercialization of the latest technology. Some countries that implement incentive programs for using alternative fuel are discussed below.

India: On March 27, 2008, a fund has been established for ambient air quality through an office memorandum by the Ministry of Finance. Ambient Air Fund account has been opened in the Delhi Pollution Control Committee (DPCC). The first program of the Ambient Air Fund is to provide subsidies for battery-powered cars. The program will help to encourage zero-emission car in this city. The Delhi administration decided to extend a 30% cost reduction for battery powered vehicle buyers. In addition, the perspective buyers of these vehicles will get a subsidy of 15%, 12.5% Value Added Tax (VAT) reimbursement. Furthermore, the registration fee and one-time road tax levy will also be reimbursed [119].

In addition, the implementation of fiscal policy by the government of Delhi has targeted CNG converting vehicle fleet. This is to maintain an effective replacement fuel CNG for transit buses that use diesel and three-wheelers that used gasoline. The action has been implemented in the early stages of the program. It started in 2000/2001 in accordance with the directive of the Supreme Court on July 28, 1998. Due to this program, it is estimated that about 3000–4000 vehicles converted to CNG in New Delhi every month. [119].

In the latest development of ministry of new and renewable energy, Government of India announced incentive plans for the electric car manufacturers in this country. Under the Incentive Plan, the Government has decided to provide a 20–25% on the ex-factory price of the electric car rebate. This means, there will be dropping by the sum of INR100,000. Due to this rebate, the Society of Manufacturers of Electric Vehicles (SMEV) expects that the sales of electric vehicle will grow double in the near future [120]. However, the incentive plan might not be a success if there is no proper road map for the program. This is because the government of India does not have any electric vehicle growth policy framework yet. Incentive program itself is a half-hearted attempt that comes so late compared to other countries. These are some mistakes that is why we cannot get the momentum for electric cars in this country [121].

California: Alternative Fuels Incentive Grant (AFIG) program is to provide financial assistance and information for alternative fuels, alternative fuel vehicles, hybrid vehicles, heavy trucks that use alternative fuels to diesel, and advanced automotive technology research, development, and demonstration. The program was created in 1992 by Act 166 and referred as AFIG. To improve and expand the program, Act 178 that passed in 2004, was formed. Then this program followed by funding up to $5000. It was available for buyers that purchased or leased eligible zero-emission vehicles (ZEVS), plug-in hybrid electric vehicles and Alternative Fuel Vehicles (AFVs) from May 24, 2007 to March 3, 2009. Furthermore, the hybrid trucks and buses Voucher Incentive Project's fund was available in the range of $10,000 to $45,000 for eligible qualified fleet vehicles. This covered the medium and heavy-duty hybrid electric vehicles to reduce the additional cost at the time of purchasing. California Public Utilities Commission voted to keep the rates, of electricity of the power electric car, stable for owners of residential, commercial and industrial, at least until the year 2013 [122].

Texas: Texas has created a variety of grant programs which are designed to encourage the use of alternative fuel vehicles (AFVs). About US$3.4–4.0 million was obtained from the General Fund. The sum of the received funds is 0.25 million of utility gross total receipt tax which is collected in each fiscal year. Compressed natural gas (CNG), liquefied natural gas (LNG), liquefied propane gas (LPG), ethanol (E85), methanol (M85), hydrogen, electricity, coal derived liquid fuels, fuels derived from biological materials and fuels determined in section 301 of the U.S. Department of Energy Secretary Policy Act of 1992 are eligible for alternative automotive fuels. Moreover, several other grants related to the alternative fuel are available in Texas. These grants include Natural Gas Initiative Program Grant, Texas Clean Fleet Program, Houston-Galveston Alternative Fuel Vehicle Grants, Dallas-Fort Worth Clean Heavy Duty Vehicle Grants, North Central Texas Clean School Bus Program, and New Technology Research and Development [123].

Electric Vehicles (EV) purchase subsidy is probably the most significant interventions incentive plan for the use of alternative fuels. The subsidy rate is usually around £4200–£5200 per vehicle. This fund is from up to hundreds of millions of pounds of government funding. Because, cheaper price of the traditional cars compared to the electric vehicles (at the moment the price at least £15,000), therefore the price difference needs a large amount of subsidies. This is necessary if the government wants to make electric vehicles competitive in the automotive market. This strategy can help to overcome potential car buyers—that are not concerned about the future of energy-efficient vehicle potential savings, but more concern about early investment cost. However, over-reliance on the government funding, in order to maintain competitiveness, brings a lot of uncertainty, especially considering the large government budget deficits in most countries. This can lead to political pressure to reduce subsidies. More importantly, the number of the electric car expanding in the market will depend upon the reducing cost of batteries technology without sacrificing vehicles performance. Despite government subsidies, breakthrough technology, and research and development help, achieving

Table 7
Electric vehicles incentives program in some countries.

Country	Initiative	Subsidy per vehicle in local currency	Max. subsidy per vehicle in £	Total amount of funding for program	Time frame
UK	"Investment in ultra-low carbon vehicles"	25% of the purchase cost, capped at £5000	£5000	£43 million	Jan 2011 to Mar 2012
		Will be reviewed in Jan 2012	–	Additional £187 million (previously announced)	2012–2014
France	"Super bonus" or "bonus" for low emissions vehicles	€2000–€5000	£4200	Not known	Until May 2010 (start date not known)
	Revised bonuses, with more detail vehicle classification	€100–€5000	£4200	Not known	From May 2010 (end date not known)
Denmark	Electric vehicles are exempt from a number of taxes	–	–	–	–
Canada	ecoAUTO rebate program	Up to $2000	£1200	$191.2 million	Mar 2007–Dec 2008
Ontario, Canada	Ontario's alternative fuel retail sale tax rebate program	8% of tax saving $750–$2000	£1200	$24 million	From 2006 to Jun 2010
Ontario, Canada	Ontario's electric vehicle incentive program	$5000–$8500	£5200	$50–85 million	From July 2010 (first 10,000 qualified applicants)

this goal cannot be guaranteed. Electric vehicle incentive plan comparisons in some countries are given in Table 7 [124].

4. Conclusions

After the recent global economic recession, several governments have concentrated on improving energy efficiency. Energy savings in the transport sector can help to reduce energy consumption and to avoid energy shortages. Incentive programs for automotive industry such as support fuel economy standards and labels can reduce energy consumption and demand in the country. In addition, many sectors will obtain tremendous benefits through the implementation of this strategy. In addition, although consumers pay higher prices for purchasing vehicles, but they will pay the lower fuel costs in return. Manufacturers would be concerned with the fuel economy of the vehicles, subsequently, they will improve competitiveness of their products in the international market. Incentive programs for the automotive industry are also shown to have positive environmental effects on reducing emissions. In addition, the study found that, there are numerous publications on the incentive programs for automotive such as support fuel economy standards and labels, particularly in developed countries, but relatively very limited in developing countries. Moreover, the passenger cars are the major energy consumers in the transport sector, therefore, introducing incentive programs for such vehicles will save a significant amount of energy in the transportation industry. The program will also provide benefits for consumers, government and the environment. Therefore, as a starting point, it is important to focus on passenger cars to reduce energy consumption. Hopefully this piece of work may be able to initiate other developing countries to implement such profitable programs in the near future.

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